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USER'S SUMMARY (Item 6A2). Addendum,

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from page 4

REPORT NO NCRE/R630 ADDENDUM

INTRODUCTION

This addendum contains a precis of R630, plus additional information on computing times, control-cards and permissible problem size. It may be regarded as superseding that document for the conversant SPAN user.

The loose-leaf binding is intended to allow for easy updating of the specification as and when program developments are implemented. The data-card specification given in R630 is no longer valid and must not be used.

NCRE PROGRAM NO 118

Title: "SPAN" IS a computer program for static and dynamic analysis of stiffened plates and grillages. p.3

Computer: CDC 6600 (SIA, London).

Language: FORTRAN.

Purpose: The analysis of plane grillages and panels under normal and in-plane static and dynamic loads. Any of the following operations may be carried out:

(i) evaluation of deflections and stresses under distributed or concentrated lateral loads.

(ii) evaluation of deflections and stresses under lateral loads combined with in-plane compressive and/or shear loads (including representation of initial distortion).

(iii) evaluation of natural frequencies and modes of vibration.

(iv) analysis of deflections and stresses under steady-state (harmonic) dynamic excitation.

(v) analysis of dynamic response to general time-dependent forces (including impulsive loads).

(vi) evaluation of elastic buckling loads and modes.

In each case, the program is applicable to:

(i) flat panels of unstiffened isotropic or anisotropic plating represented by plate elements only.

(ii) flat stiffened panels represented by a combination of beam and plate elements.

(iii) grillages represented by beam elements only.

Method: Full details of the methods employed are given in NCRE report R630. For present purposes it is sufficient to say that the program is based on the finite element method; the elements themselves being represented by two-node Bernoulli-Euler beams, with shear and torsion stiffness added, and triangular three-node Zienkiewicz plates. Geometrical representation of the structure is aligned to the standard concept of discrete structural elements connected together at node points, to which constraint and load conditions are also referred.

General Notes: A data generation facility is incorporated in the program. This may be used either to generate a full data set in-core and then proceed directly with the calculation, or to punch a full data set on cards, perhaps for submission to the computer after some minor alteration. The second

usage is particularly helpful when only slight departures from the permitted regular structure and load configurations occur.

Data specification is given below in three sections, "General", "General using Datagen" and "Specific Data for Each Calculation Type". Although cards must be prepared in that order, the last section should be perused first to ascertain the calculation type number and to give background on the total data requirement.

Idealisation: The structure is reduced to a set of node points with interconnecting beam and plate elements, as appropriate. The nodes are numbered consecutively from 1 to NN, and a right-handed cartesian axis system should be assumed, with rotations and applied moments taken as clockwise positive when looking in the co-ordinate directions. It is possible to change to a local axis system by specifying nodal transformations from the initial system. If this option is used, applied forces and restraints, and calculated deflections are all referred to the local system. Note that the structure to be analysed is assumed to lie in the x-y plane and to possess three degrees of freedom at each node point. These are deflection in the z direction and rotations about the x and the y directions, taken in that order.

Out-of-plane loads are applied as either point forces and moments acting at nodes, line-loads (uniformly distributed forces) acting on beams, or normal pressure acting on plates. In-plane loads take the form of an axial force for beams, and two direct stresses and a shear stress for plates. Tension is assumed positive throughout.

Before attempting to idealise the structure, the section "Problem Size" should be consulted for information on the permissible maximum number of nodes, number of elements etc.

It is not always easy to allocate suitable stiffness properties to the individual elements, and particular mention is made here of the situation existing when a grillage is comprised of a mixture of beams and plates. Since no eccentricity is allowed, each beam inertia must be calculated assuming a part of the plate breadth to act with the beam as an effective flange. The plates themselves are specified as normal (thus accounting for local plate-bending behaviour). If in-plane stresses are present, the beam axial forces are calculated on the basis of the nominal stress multiplied by the enhanced cross-sectional area, derived from the plate-beam combination. Again, the plates are specified as normal. At present, the problem of deciding on a value to assume for the breadth of plate acting with a given beam is not completely resolved. However, the following figures are suggested as an approximate guideline.

Nominal Plate Breadth / Plate Thickness (= b/t)	Effective Breadth / Nominal Breadth	
	Compressive Conditions	Tensile Conditions
b/t < 40	1.0	0.8
b/t = 40 → 50	1.0 → 0.75	0.8
b/t = 50 → 80	0.75 → 0.5	0.8
b/t > 80	(40) x (t)	0.8

Data Cards: General

Card 1: (Up to 80 alphameric characters)

TITLE

Card 2: FORMAT(I5)

NFLAG = 0 Unabridged data input (E format)

= 1 Unabridged data input (F format)

= -1
= -2 } Datagen facility used. See later

Card 3: FORMAT(10I5,E15.8)if NFLAG = 0

FORMAT(10I5,F.10.0)if NFLAG = 1

NC Calculation type number (1 → 6)

NN Number of Nodes

NB Number of beam elements

NP Number of plate elements

NL Number of lateral load conditions

NNR Number of restrained nodes

NNL Number of loaded nodes

NBSEC Number of beam sections

NPSEC Number of plate sections

NOOT Output parameter (= 99 if diagnostic printout required)

(= 0 otherwise)

VI Axial load parameter (constant multiplier acting on beam axial forces, normally set equal to one)

Card 4: omit if NNR = 0

FORMAT(4E15.8)if NFLAG = 0

FORMAT(4F10.0)if NFLAG = 1

NODE NUMBER

Z RESTRAINT) = 0, free

θ_x RESTRAINT) = -1, clamped

θ_y RESTRAINT) = +VE, elastic restraint

(NOTE: NNR cards required, 1 set of restraints per card)

Card 5*: omit if NNL = 0

FORMAT(E15.8)if NFLAG = 0

FORMAT(F10.0)if NFLAG = 1

NODE NUMBER

Card 6*: omit if NNL = 0

FORMAT(3E15.8)if NFLAG = 0

FORMAT(3F10.0)if NFLAG = 1

Q_z Lateral nodal load

M_x Moment about x

M_y Moment about y

*(NOTES: 1. Cards 5 and 6 are read together, card 6 being repeated NL times. Taking cards 5 and 6 as a group, there are NNL groups of data.

2. Constraint and load data refer to the local nodal axes - see Figure 1).

Card 7: omit if NB = 0

FORMAT(10X,4E15.8/2E15.8)if NFLAG = 0

FORMAT(10X,6F10.0)if NFLAG = 1

I Inertia constant

J Torsion constant

A_s Shear area

Z Distance from NA to outer fibre

E Young's modulus

G Shear modulus

(NOTES: 1. Element identification number may be inserted in the 10X gap - this is ignored by SPAN.

2. If NFLAG = 0, 2 cards are required:

Card 7a contains I, J, A_s and Z, and

Card 7b contains E and G.

3. Card(s) 7 is repeated NBSEC times).

Card 8: omit cards 8, 9 and 10 if NP = 0

FORMAT(2E15.8)

CO-ORD(1,I) X Co-ord of node

CO-ORD(2,I) Y Co-ord of node

- NN cards, ie one for each node. Specify sequentially, commencing at one.

Card 9*: FORMAT(E10.2,3I5,5E10.2)

TH(I) - Plate thickness

(-ve if stiffness identical to previous plate)

NXYCO(1,I))
NXYCO(2,I)) Node numbers of plate element vertices, listed anti-clockwise in the positive Z direction
NXYCO(3,I))

XYRES(1,I)) Position at which stresses are required) If zero, centroidal values assumed by SPAN
XYRES(2,I))

TRN1(I))
TRN2(I)) Angles in radians between local nodal and global XY planes. Measure from local to global, clockwise positive about $\overline{Z}$, RH axes assumed (see Figure 1)
TRN3(I))

Card 10*: omit if TH < 0
FORMAT(3E15.8/6E10.2)

SIG(1) membrane stress σ_{xx})
SIG(2) membrane stress σ_{yy}) Tensile positive
SIG(3) membrane stress σ_{xy})

RPEC(1 → 6) plate elastic rigidities

eg isotropic case: h = TH, E = Young's Modulus,

ν = Poisson's Ratio

$$\begin{bmatrix} RPEC(1) & RPEC(2) & RPEC(4) \\ & RPEC(3) & RPEC(5) \\ SYM & & RPEC(6) \end{bmatrix} = \begin{bmatrix} \frac{Eh^3}{12(1-\nu^2)} & \frac{\nu Eh^3}{12(1-\nu^2)} & 0 \\ & \frac{Eh^3}{12(1-\nu^2)} & 0 \\ SYM & & \frac{Gh^3}{12} \end{bmatrix}$$

*(NOTE: repeat cards 9 and 10 NP times).

Card 11**: omit if NB = 0

FORMAT(4E15.8/3E15.8)if NFLAG = 0

FORMAT(7F10.0)if NFLAG = 1

BEAM ELEMENT NUMBER (-VE if stiffness and distributed load identical to previous beam, otherwise no limitations)

NODE NUMBER at $x = 0$ (local beam axis)

θ at $x = 0$ (angle in degrees between local beam axis and local nodal axis. Measure from local nodal to local beam axis - clockwise positive about z, RH axes assumed (see Figure 1))

NODE NUMBER at $x = b$ (this must be the higher of the 2 beam node numbers)

θ at $x = b$

OUTPUT PARAMETERS
(= 0, No beam stresses or forces output
(= 2, Beam stresses, forces and displacement output for both ends
(= 3, Ditto for both ends plus mid-position
(= n, Ditto for n equally spaced positions

AXIAL FORCE Tensile positive

Card 12**: omit if NB = 0 or beam el No specified -VE

FORMAT(4E15.8)if NFLAG = 0

FORMAT(4F10.0)if NFLAG = 1

TYPE NUMBER (double ended = 1)

SECTION IDENTIFIER

b (element length)

LATERAL LINE LOAD PARAMETER (= 0, no lateral line load
(= 1, otherwise

Card 13**: omit if NB = 0 or beam el No specified -VE, or lateral load parameter specified zero

FORMAT(4E15.8)if NFLAG = 0

FORMAT(8F10.0/8F10.0)if NFLAG = 1

w_1, w_2, w_3, ., ., ., w_{NL}) Line load intensities for each of NL load conditions

**(NOTES: 1. Cards 11 → 13 repeated NB times

2. If NFLAG = 0, card 11 is split into 2 cards, 11a and 11b - see format

3. If NFLAG = 1, card 13 is split into 13a and 13b - see format).

NOW REFER TO THE SECTION "SPECIFIC DATA FOR EACH CALCULATION TYPE" FOR DETAILS OF ANY ADDITIONAL CARDS THAT MAY BE REQUIRED.

<u>Data Cards:</u> <u>General Using Datagen</u>

Card 1: (Up to 80 alphameric characters)

TITLE

Card 2: FORMAT (I5)

NFLAG = -1 Full data set generated within the computer and solution attempted

= -2 Full data set punched on cards. No solution

Card 3: FORMAT(6I10,F10.0)

ND Data type parameter (1 or 2, see Figure 2)

NC Calculation type number (1 → 6)

NL Number of lateral load conditions

NOOT Output parameter (= 99 if diagnostic printout required)

(= 0 otherwise)

NOUTX Output for x beams)
NOUTY Output for y beams)

(= 0, No beam stresses or forces output
(= 2, Beam stresses, forces and displacement output for both ends
(= 3, Ditto for both ends plus mid-position
(= n, Ditto for n equally spaced positions

V1 Axial load parameter (constant multiplier acting on beam axial forces, normally set equal to one)

Card 4: FORMAT(3F10.0)

RL X direction grillage length)
B Y direction grillage length) complete grillage, before symmetry

H Thickness of plating (uniform)

Card 5: omit cards 5, 6 and 7 if H = 0

FORMAT(6F10.0)

RPEC (1 → 6) plate elastic rigidities, see page 8

Card 6: FORMAT(3F10.0)

SIG(1) σ_{xx})
SIG(2) σ_{yy}) membrane stress (tensile positive)
SIG(3) σ_{xy})

Card 7: omit if NL = 0

FORMAT(8F10.0)

Q(I) uniform lateral pressure, I = 1 → NL

Card 8: FORMAT(2I10)

NBX no of beams parallel to x-axis

NBY no of beams parallel to y-axis

(NOTES: 1. NBX and NBY refer to the complete grillage, even if axes of symmetry are to be assumed

2. Edge beams are not allowed when using the data-generation facility

3. If NBX and NBY are both -VE, beams are considered to be imaginary and only plate data is generated).

Card 9: FORMAT(I10,3F10.0)

I Side 1 edge restraint parameter (see Figure 3)

Z Elastic spring constant)
θ_x Elastic spring constant) input only if
θ_y Elastic spring constant) I = 4

Card 10: as above, but for side 2

Card 11: as above, but for side 3

Card 12: as above, but for side 4

Card 13*: omit cards 13, 14 and 15 if NL = 0

FORMAT(I10)

II Concentrated load (= 0, omit cards 14 and 15
data flag (= 1, supply data

Card 14*: FORMAT(I10)

K Number of loaded nodes for i^{th} load condition (= 0 if no loads for that condition - omit Card 15)

Card 15*: FORMAT 4(2I5,F10.0)

NXYCO(1) X beam number)
NXYCO(2) Y beam number) 4 sets per card
CNLF Applied nodal force)
(Specify full value on axis of symmetry)

*(NOTES: 1. Nodes are defined by beam intersections, X beams are numbered from 0(Y = 0 edge) to NBX+1. Ditto for Y beams.

2. Forces are only specified for nodes remaining after imposition of symmetry, if any.

3. Cards 14 and 15 are read together, card 15 being repeated K times. Taking cards 14 and 15 as a group, there are NL groups of data.

TYPE 1 DATA

X beam data (omit if NBX = 0)

Card 16: FORMAT(8F10.0)

DX(I)	Y direction spacing of X beams
V(M3)*	Inertia constant
V(M3+1)*	Torsion constant
V(M3+2)*	Shear area
V(M3+3)	Distance from NA to outer fibre
V(M3+4)	Young's modulus
V(M3+5)	Shear modulus
RPX*	Axial force (tensile positive; if zero punch 0)

*(NOTE: Specify full values on axis of symmetry).

Card 17: omit if NL = 0 or NBX and NBY both -VE

FORMAT(I10)

J = 0, no line load

= 1, supply NL line loads

Card 18: omit if NL = 0 or NBX and NBY both -VE or J = 0

FORMAT(8F10.0)

WX(JJ) line load intensities, supply NL values (specify full value on axis of symmetry)

Y beam data (omit if NBY = 0)

Card 19: repeat card 16 using data for Y beams. If Y beams have same section as X beams, set DY -VE (any number) and leave rest of card blank, unless last X beam lies on an axis of symmetry (in this case supply full set of Y beam data).

Card 20:)
Card 21:) repeat cards 17 and 18 as necessary

TYPE 2 DATA

X beam data (omit if NBX = 0)

Card 16**: FORMAT(8F10.0)

DX(L)	Y direction spacing from previous X beam to present X beam (or from Y = 0 for first beam)
RPX(L)*	Axial force (tensile positive; if zero punch 0)

V(M3)* Inertia constant (-1 if similar beam already specified)

V(M3+1)* Torsion constant (or section number of similar beam already specified)

(NOTES: 1. Beam section numbers are allocated sequentially from 1 for all beams with positive inertia constant .

2. Omit the following card 16 entries if the inertia constant is -1).

V(M3+2)* Shear area

V(M3+3) Distance from NA to outer fibre

V(M3+4) Young's modulus

V(M3+5) Shear modulus

*(NOTE: Specify full values on axis of symmetry).

Card 17**: omit if NL = 0 or NBX and NBY both -VE

FORMAT(I10)

I = 0, no line load

= 1, supply NL line loads

Card 18**: omit if NL = 0 or NBX and NBY both -VE or I = 0

FORMAT(8F10.0)

WX(II) line load intensities, supply NL values (specify full values on axis of symmetry)

**(NOTE: Cards 16, 17 and 18 are repeated NSYMX times, where NSYMX is the number of beams remaining after imposing symmetry. Beams lying on an axis of symmetry are included in this figure).

<u>Y beam data</u> (omit if NBY = 0)

Card 19:)
Card 20:) repeat cards 16, 17 and 18 as necessary
Card 21:)

<u>Data Cards</u>: <u>Specific Data for Each Calculation Type</u>

Notation: $[K]$ = matrix of bending stiffness coefficients

$[K_G]$ = geometric matrix - contains additional bending stiffness coefficients arising from in-plane stresses

$[\delta]$ = deflection vector

$[R]$ = static load vector

λ = eigenvalue

$[M]$ = diagonal matrix of masses and mass moments of inertia

$[C]$ = diagonal matrix of damping coefficients

$[F]$ = vector of time dependent force amplitudes

ω = angular frequency } relating to $[F]$
ε = phase angle }

Lateral Load Only

Type Number, NC = 1

Governing Eq $[K]\ [\delta] = [R]$

No additional data required

Combined Lateral and Axial Load

Type Number, NC = 2

Governing Eq $\Big[[K] + [K_G]\Big][\delta] = [R]$

No additional data required

Natural Frequencies and Mode Shapes

Type Number, NC = 3

Governing Eq $\Big[[K] + [K_G] - \lambda\ [M]\Big][\delta] = 0$

Card 1: FORMAT(I5)

IREAD = 0 stiffness matrix read from cards (upper triangle only, stored in columns)

= 1 matrix generated by SPAN

Card 2: omit if IREAD = 1

FORMAT(I5)

NMAT = order of matrix

Card 3: omit if IREAD = 1

FORMAT(8F10.0)

K(I), I = 1→M stiffness matrix, where M = (NMAT) x (NMAT+1)/2, (upper half only, in cols.)

Card 4: FORMAT(2I5)

NMODE = number of vibration modes required in result

NDOF = number of significant degrees of freedom (relating to non-zero masses)

Card 5*: FORMAT(I5,F10.0)

NDF(J) = degree of freedom number (degrees of freedom re-numbered after imposing constraints but including zero mass (ie non-significant) values)

SM(J) = mass

*(NOTE: Repeat Card 5 NDOF times).

Steady State Response

Type Number, NC = 4

Governing Eq $[M]\ [\ddot{\delta}] + [C]\ [\dot{\delta}] + \Big[[K] + [K_G]\Big][\delta]$

$= [F \cos(\omega t + \epsilon)]$

Card 1: FORMAT(2I5,F10.0)

NDOF = number of significant degrees of freedom (relating to non-zero masses)

NDAMP (= 0, no damping

(= 1, damping

w = forcing function frequency (radians/sec)

Card 2*: FORMAT(I5,4F10.0)

NDF(I) = significant degree of freedom number (degrees of freedom re-numbered after imposing constraints but including zero mass (ie non-significant) values)

SM(I) = mass

C(I) = damping coefficient

F(I) = exciting force amplitude

PAF(I) = phase angle relating to F

*(NOTE: Repeat Card 2 NDOF times).

<u>Transient Response</u>

Type Number, NC = 5

Governing Eq $[M]\,[\ddot{\delta}] + [C]\,[\dot{\delta}] + \Big[[K] + [K_G]\Big][\delta]$

$= [F]$

Card 1: FORMAT(4I10)

K2 = number of exciting forces

K3 = number of imposed displacements

K4 = 0

K5 (= 0 if λ is zero at all times

(= 1 if λ is non-zero but constant

(= 2 if λ is time-dependent

(= 3 if λ is constant within each integration range

(NOTE: λ is a scale factor acting on K_G, the geometric stiffness)

Card 2: FORMAT(8F10.0) as many cards as necessary

List NMAT masses followed by NMAT damping coefficients, where NMAT is the order of the stiffness matrix after constraining. Do not start a new card for the damping coefficients unless the previous card is full.

(NOTE: If zero masses are given, the corresponding degrees of freedom are condensed out of the solution and re-inserted later on, in the results stage).

Card 3: omit if $K_5 = 0$

FORMAT(F10.0)

λ

Card 4: omit if $K_3 = 0$

FORMAT(8F10.0)

Degree of freedom numbers for imposed displacements

Card 5: FORMAT(I10)

NIR = number of integration ranges

Card 6: FORMAT(8F10.0)

Imposed displacements vector followed by Initial velocity vector, of length NMAT in each case

(do not start velocity vector on a new card unless previous one full. If vectors null, punch zero's)

Card 7: omit if $K_2 = 0$

FORMAT(4(I10,F10.0))

Degree of freedom number for forces, and force magnitudes

Card 8: omit if $K_3 = 0$

FORMAT(4(I10,F10.0))

Degree of freedom number for imposed displacements, and displacement magnitudes

Card 9: FORMAT(I10,F10.0,3I10)

Number of time steps

time step

Number of time steps between each printout

K_6 control parameter:

(= 0, compute new F

(= 1, compute new reduced F K

(= 2, compute new reduced F K M C

K_8 (= 0, if exciting forces and imposed displacements constant

(= 1, if exciting forces and imposed displacements time-dependent

Card 10*: FORMAT(F10.0)

λ, needed if $K_5 = 2$ and $K_6 \neq 0$

Card 11*: FORMAT(4(I10,F10.0))

Degree of freedom number for forces, and force amplitudes; needed only if K_8 and K_2 non-zero. Specify forces K_2 times

Card 12*: FORMAT(4(I10,F10.0))

Degree of freedom number for displacements, and displacement amplitudes; needed only if K_8 and K_3 non-zero, K_3 times

*(NOTE: Cards 10, 11 and 12 are repeated NTS times).

Card 13: FORMAT(F10.0)

λ, required for second and subsequent integration ranges (needed only if $K_5 = 3$)

Repeat data from card 7 for next integration range, as necessary

Linear Buckling**

Type Number, NC = 6

Governing Eq $\left[[K] + \lambda\,[K_G]\right][\delta] = 0$

Card 1: FORMAT(3I5,2F10.0)

NMODE Number of buckling modes required in results. If left unspecified, value set by program = 4

IREAD Option to read in matrices K and K_G. Specify zero if not required, 1 otherwise

ICON Number of degrees of freedom to be condensed out of the solution

GP, GQ Lower and upper limits for the required buckling loads* (order immaterial). If left unspecified, GP = 0.001, GQ = 1000

*(NOTE: Use the reciprocal of the anticipated loads for the purpose of specifying limits).

Card 2: omit if ICON = 0

FORMAT(16I5)

N(I) I = 1 → ICON. Degree of freedom numbers (refers to re-numbered set, after imposing constraints). Repeat card as necessary.

Card 3: omit if IREAD = 0

FORMAT(I5)

NMAT Order of matrices to be read in

Card 4: omit if IREAD = 0

FORMAT(2F10.0)

K(I), K_G(I) I = 1 → NMAT(NMAT + 1)/2

Conventional and geometric stiffness matrices. Supply upper half only (in columns)

**(NOTE: It should be remembered that the buckling load, calculated and printed by the program, is a uniform multiplier acting on the beam axial forces and plate stresses. The actual buckling load is arrived at by multiplying the printed buckling load by the values allotted to the input parameters "SIG(1,2,3)", "AXIAL FORCE", or "RPX", as appropriate).

Output: General

For all calculation types, the title is printed out followed by the value of the control parameter "NFLAG". If NFLAG = -1 (ie the datagen facility is used) a list of generated input data is printed, followed by an array containing the degree of freedom numbers eliminated by constraint conditions (the NDE array). If NFLAG = -2 a list of generated input data is printed, and an unabridged card deck is punched in E format. The run is then terminated.

Diagnostic output may be obtained by setting the parameter "NOOT" equal to 99.

Lateral Load Only, and Combined Lateral and Axial Load

After the general heading "NODAL DISPLACEMENTS AND ROTATIONS", the following results are printed for each lateral load condition:

a. Deflections and rotations for each node.

b. Beam element displacements, moments, forces and bending stresses at each stress point (specified in the input data).

c. Plate element moments, computed at centroids when the datagen facility is used.

Natural Frequencies and Mode Shapes

Frequencies (radians/sec) and mode shapes are printed out for the lowest NMODE resonant frequencies.

Steady State Response

The following results are printed:

a. Displacement amplitudes and phase angles (radians) for each degree of freedom (remaining after imposing constraints).

b. Beam element displacement, moment, force and bending stress amplitudes, together with corresponding phase angles, at each stress point.

c. Plate element moment amplitudes and phase angles, computed at centroids when the datagen facility is used.

Transient Response

The following results are printed:

a. List of options selected.

b. Tables giving bending stiffnesses (K_o), geometric stiffnesses (K_G) and modified stiffness matrices.

c. For each time step, the displacement, velocity and acceleration for each degree of freedom.

d. If the calculation includes more than one integration range, 'b' and 'c' are repeated.

Linear Buckling

Buckling loads and mode shapes are printed out for the lowest NMODE eigenvalues. The modal vector contains deflections, listed in rows, for those degrees of freedom that remain after imposing constraints and carrying out condensations (if any).

Problem Size: General

When using the datagen facility the following limitations apply:

1. Maximum no of nodes = 91.

2. Maximum no of loadcases = 10.

3. Total no of X and Y beams, taken collectively, should not exceed 24.

For any calculation:

4. Maximum no of degrees of freedom that may be condensed out of the solution = 80.

Calculation Types 1 and 2

1. Maximum no of nodes = 91.

2. Maximum no of beam elements = 162.

3. Maximum no of plate elements = 150.

4. Maximum no of restrained nodes = 50.

5. Maximum no of loadcases (NL) = 2.

For smaller calculations:

6. NL = (5859 -(31xNB))/2, 8100/(27xNP), or 768/(3xNN), whichever is least.

Calculation Types 3 and 6

1. Maximum no of nodes = 64.

2. Maximum no of degrees of freedom, remaining after imposing constraints = 150.

3. Maximum no of eigenvalues (ie buckling loads or resonant frequencies) = 5.

4. Maximum no of beam elements = 162.

5. Maximum no of plate elements = 150.

6. (Type 3 - Minimum no of significant degrees of
   (freedom = 70.
   (Type 6 - Maximum no of insignificant degrees
   (of freedom (ICON) = 80.

For smaller calculations:

7. Maximum no of eigenvalues = 768 ÷ (no of degrees of freedom remaining after imposing constraints).

8. Type 3 - Minimum no of significant degrees of freedom = (no of degrees of freedom remaining after imposing constraints) -80.

<u>Calculation Type 4</u>

For the undamped case, type 3 limitations apply.

If damping is specified:

1. Maximum no of significant degrees of freedom = 75. The minimum value is zero.

2. In other respects, type 3 limitations apply.

<u>Calculation Type 5</u>

1. Maximum no of degrees of freedom, remaining after imposing constraints = 36.

2. In other respects, type 3 limitations apply.

<u>Error Messages</u>: Various data checks are carried out by SPAN, and if the data is found to be inadmissible an error message will result. Advice on how to interpret such a message is given in NCRE Report R630. Generally, experience shows that FORMAT errors or missing data cards are by far the most probable cause of run failure.

<u>Control</u>: The run stream is constituted as follows:

```
aaa,CM305000,Taa.
ACCOUNT,aaaaaa,aaaa,aaa.
VSN(OWNER = 124900,T = 2440)
LABEL(T,R)
COPYBF(T,BSPAN)
REWIND(BSPAN)
LOAD(BSPAN)
EXECUTE(SPAN)
7/8/9
data cards
6/7/8/9
```

Run Times: There is a considerable variation in run time, for a given problem size, depending on the type of calculation being executed. The following table gives some typical figures:

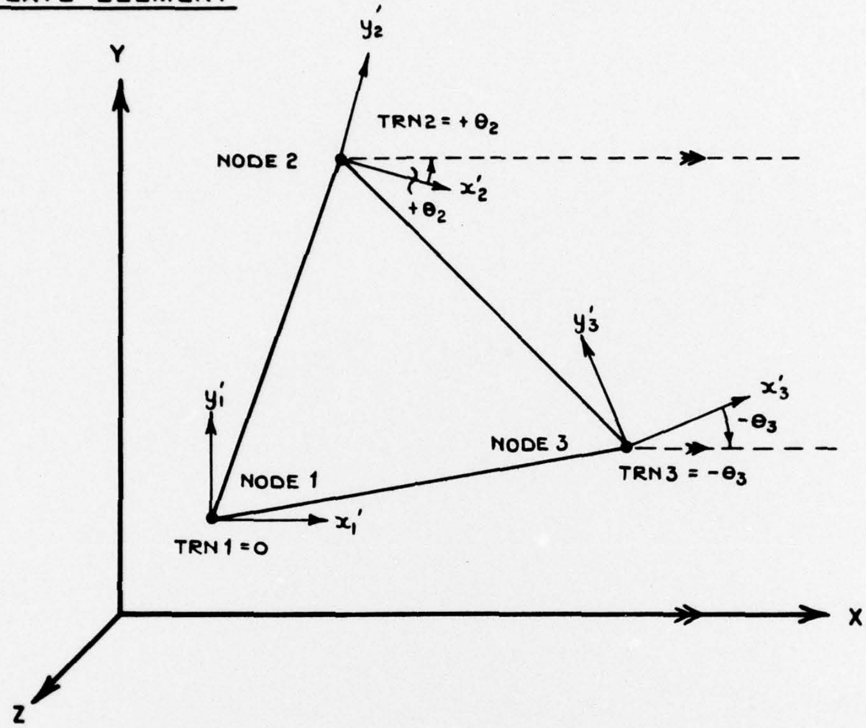
Calculation Type No =		1	1	3	4	5	6
No of Nodes	=	9	45	8	5	4	32
No of Beams	=	0	52	7	4	3	0
No of Plates	=	8	0	0	0	0	42
No of Degrees of Freedom in Final Solution	=	12	83	14	9	3	63
Total No of Time Steps	=	/	/	/	/	750	/
CPU Time (Secs)	=	0.4	3.0	0.1	0.2	26.9	6.5

<u>Programmed and Implemented</u> by G C Mitchell and others

TRANSFORMATION CONVENTION

THE LOCAL NODAL AXES ARE x', y'

a) PLATE ELEMENT



b) BEAM ELEMENT

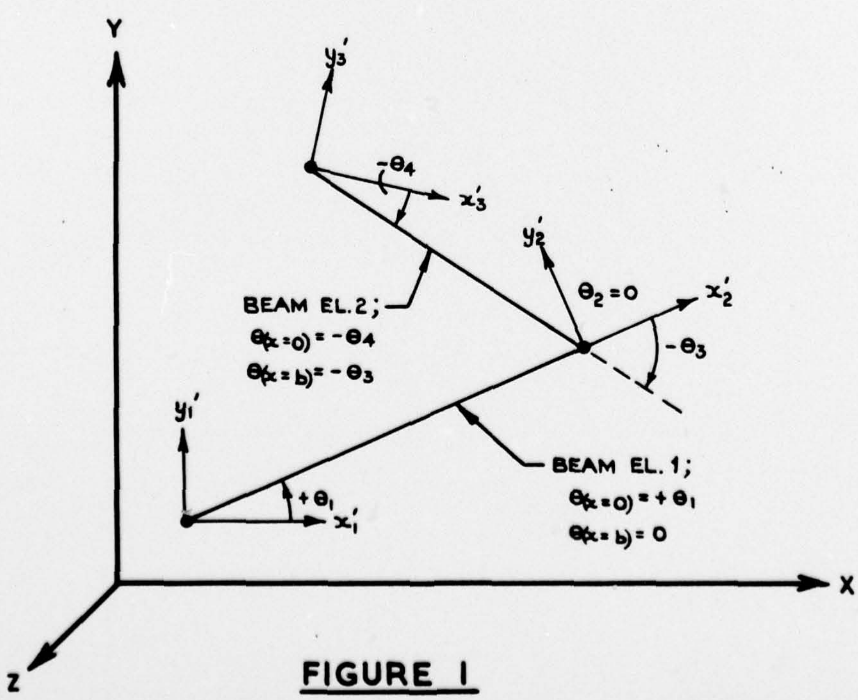
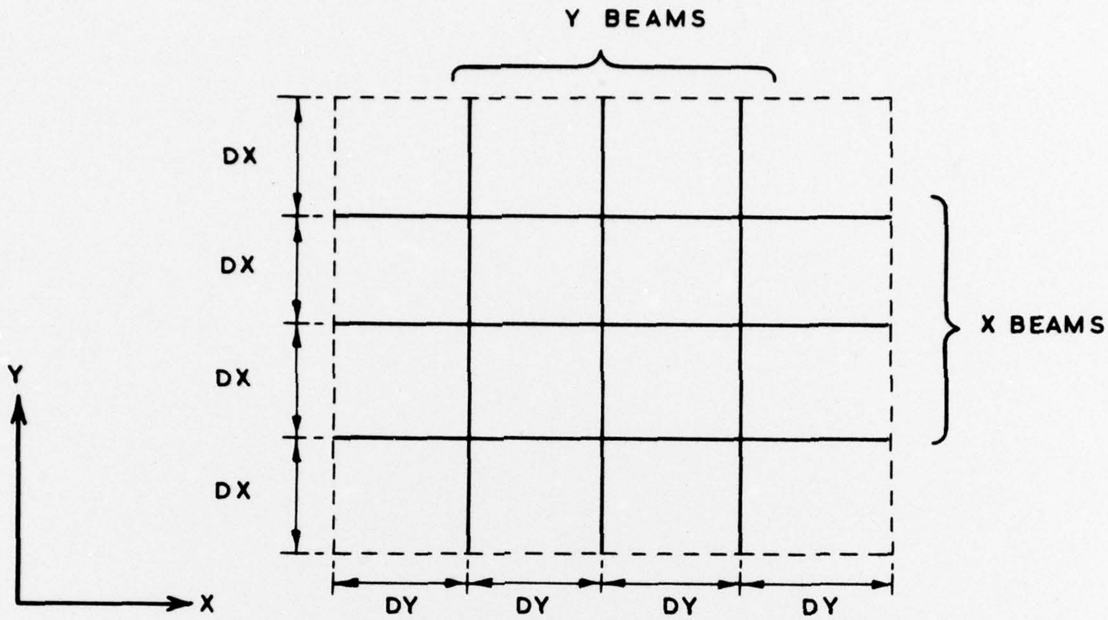


FIGURE 1

GRILLAGE TYPES FOR DATAGEN FACILITY

TYPE 1 – REGULAR GRILLAGE (ORTHOGONAL)



NOTES:- 1. ALL X BEAMS HAVE SAME SECTION
ALL Y BEAMS " " "

2. SPACINGS DX ARE CONSTANT
SPACINGS DY " "

TYPE 2 – IRREGULAR GRILLAGE (ORTHOGONAL)

NOTES:- 1. X AND Y BEAMS MUST HAVE CONSTANT SECTIONAL PROPERTIES ALONG THEIR LENGTHS

2. EACH X AND Y BEAM MAY HAVE A DIFFERENT SECTION FROM ITS NEIGHBOUR

3. SPACINGS DX AND DY MAY VARY FROM BEAM TO BEAM

FIGURE 2

GRILLAGE EDGE RESTRAINT CONDITIONS

CARDS 9, 10, 11, 12:

I = 1. UNRESTRAINED
2. SIMPLY SUPPORTED
3. EDGE CLAMPED
4. EDGE ELASTICALLY RESTRAINED
5. PLANE OF SYMMETRY AT MID SPAN
6. PLANE OF ANTI - SYMMETRY AT MID SPAN

TYPES 5 AND 6 EDGE RESTRAINTS CAN BE APPLIED TO SIDES 3 AND 4 ONLY

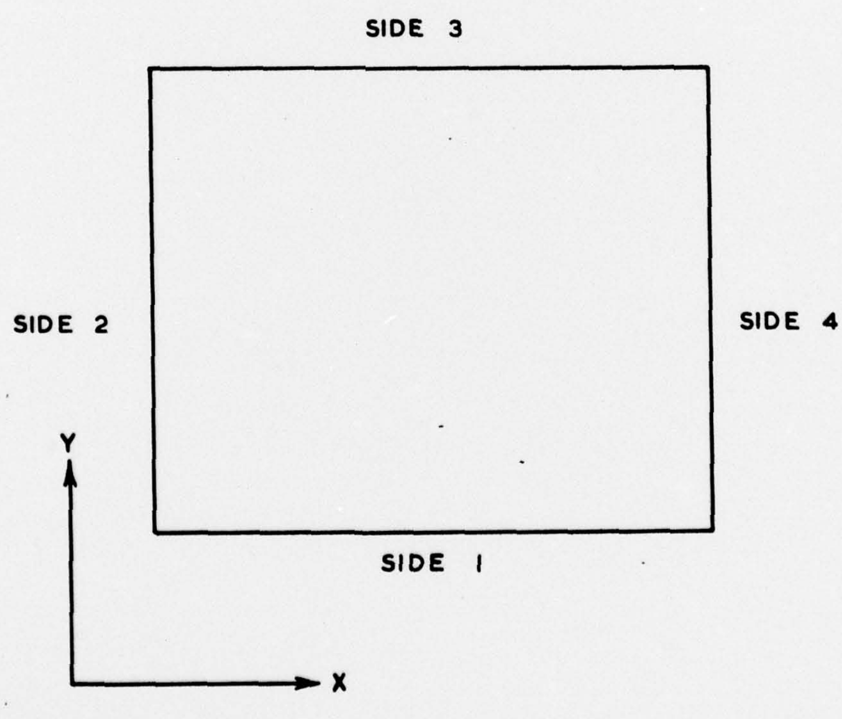


FIGURE 3